

Erosion process in ski centres of Serbia

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1. Abstract

Thanks to investments in tourism on the territory of Serbia, four new ski centres (Stara Planina, Divčibare and Zlatibor, Crni Vrh) have been launched. Parallel, with new ski centres, in Serbia, we have several older ski centres, such as Kopaonik, Brezovica and Goč.

Because of very steep slope (slope almost 40%), precipitation (1000-1200mm), adverse geological and pedological types of soil, displaced biological cover (forest and grass), erosion process (landslide erosion, small ridges, furrows and very deep gullies) culminate.

This paper will present all the above areas which are considered as erosion areas, and for the very short time, influenced by human activities, they became areas attacked by excessive erosion (deep furrows and gullies). With good landscape planning and design, with technical, biotechnical and biological erosion control structures, these areas will be protected against erosion processes and land degradation.

Key words: ski trail, erosion process, gully erosion.

2. Introduction

Erosion and torrential regions characterise the greatest part of the territory of Serbia, which is the consequence of its geo-morphological characteristics. The hilly and mountain regions which cover 3/4 of Serbian territory have a natural predisposition for the development of erosion and torrential processes. Almost all these areas are attacked by erosion processes, and a half of the area is characterised by strong intensities of erosion.

The issue of soil erosion is very complex, because of the diversity of causes and consequences of erosion processes. Soil erosion is a natural phenomenon, under the impact of a great number of factors (geomorphological, geological, pedological, meteorological, hydrological, biological, etc.). In addition to the natural aspect, the anthropogenic factor also plays an important role in the development of erosion processes. Land use is especially significant in the areas with a natural predisposition to soil erosion.

Erosion processes in the field have two basic effects:

- direct effect in the zone of erosion ("on-site effect"), which is manifested by the degradation of the soil and the natural environment;
- indirect effect outside the zone of erosion ("off-site effect"), which is manifested by the transport of erosion sediment through the hydrographic network of the catchment.

Erosion processes and sediment transport are widely distributed throughout the world, because of which they are parts of many spheres of human activities. All the main economic activities - agriculture, forestry, water management, industry, civil engineering, etc., all have several contact points with erosion issues. Also, soil erosion endangers some non-economic activities – environmental protection, recreation, etc. Consequently, the economic and social effects of soil erosion are very significant.

3. Present state of ski areas in Serbia

During the recent years in Serbia, the development of ski tourism has become rather expansive. In addition to our old ski centres, such as Kopaonik, Brezovica, Zlatibor and Goč, some new ones have been launched (Stara Planina, Crni Vrh, Divčibare, Suva Planina). The investments that are invested in these ski centres are measured by millions of Euros.

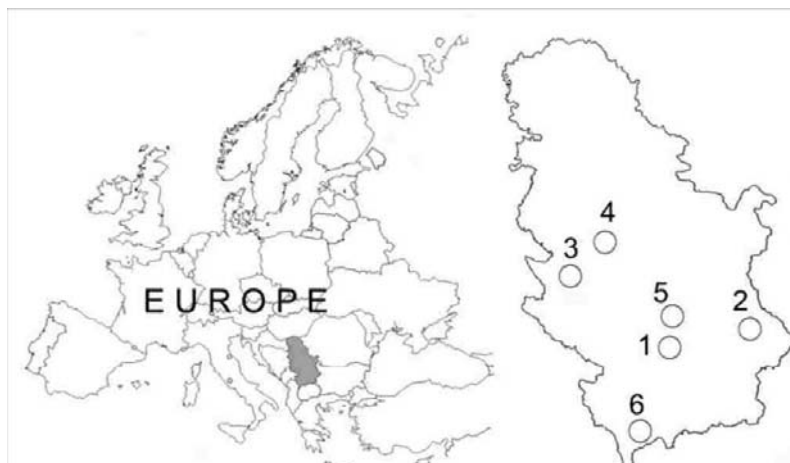


Figure 1 Position of the most important Ski Centres in Serbia:
1 - Kopaonik; 2 - Stara Planina; 3 - Zlatibor; 4 - Divčibare; 5 - Goč; 6 - Brezovica



Figure 2 Ski Centre "Kopaonik"



Figure 3 Ski Centre "Stara Planina"

A major ski centre in Serbia "Kopaonik" is located on the Kopaonik Mountain (Figure 2), in the area of the National Park. This ski resort offers about 47 km of ski slopes for alpine skiing and about 18 km of ski slopes for cross-country skiing, interconnected with 22 chairlifts and ski lifts. The total investment in the construction of new ski slopes and chairlifts between December 2004 and March 2007 amounts to about 16,500,000 €.

Second largest ski centre is being built on the biggest mountain in East Serbia - Stara Planina, which runs along the Serbian-Bulgarian border (Figure 3). While the preparation of the Master Plan for the new ski resort "Stara Planina" is under way, three ski slopes of 3.700m in length and appropriate installations were completed during the first construction phase. In December 2007, a new detachable quad chair lift and one ski lift were started up. Total value of these investments was about 4,000,000 €.

Construction of another new ski slope has been started in the proximity of the locality Divčibare on the Maljen mountain in 2006. By the end of 2006, a construction of one 850 m long ski slope with double chair lift had begun, totalling to approximate investment of 1,000,000 €.

In addition to these ski resorts, in which considerable assets were invested in past several years, there are many other existing ski areas in Serbia. "Goč – Dobro Vode" with two ski slopes, each of 300m in average length, equipped with two ski lifts for beginners and kids, and one 1.400m long ski slope equipped with one 1.150m single chairlift. "Goc – Dobro Vode" resort also has one ski jumping hill, appropriate for ski jumping training and practice. "Iver–Tara" ski resort has three ski slopes of total 4km length, with one 1.400 m long ski lift.

Total investment was approximately 1,000,000 €. "Goc–Vrnjačka Banja" has one ski slope of approximate 600 m length, equipped with one ski lift. Smaller ski centres include "Tornik – Zlatibor" (Figure 7), "Tara – Beli Bor – Mitrovac" (two ski slopes 150 m and 450 m long with two ski lifts), "Zlata – Nova Varoš", "Sjenica", "Golija –

Novi Pazar”, “Bojanine Vode – Suva Planina”, and “Rajkovo–Majdanpek”. Several locations have at least one baby ski lift:

“Košutnjak – Beograd”, “Mackov Kamen – Krupanj”, “Kušici–Ivanjica”, “Jabuka–Prijepolje”, “Savaca – Borsko Jezero”, “Stol–Bor”, “Rtanj–Boljevac”, “Midžor–Piroć”, “Rudnik”, “Kaona–Lucani”, “Kamenicki Vis – Niš”, “Mali Jastrebac – Niš”, “Lukovska Banja”, “Kraljevica–Zajecar”, and “Rakovac – Srem”.

4. Erosion processes in ski centres in Serbia

Erosion occurs on the slopes, consequently relief is the basic factor of erosion. In ski centres throughout Serbia, the slopes range up to 40%. Still, the occurrence of erosion on a terrain, even if the slopes are very steep, depends on many other factors: geology - bedrock, climate, vegetation cover, land use, absence of protection measures, etc.

Erosion in ski centres throughout Serbia occurs in the following forms:

- sheet
- rill
- gully
- landslide.

Sheet erosion occurs everywhere on the slopes during more intensive rainfall or snow melting. It is a rather uniform removal of the surface layer of the soil from the sloped sides. Small rills appear on the soil surface, which can easily be smoothed already by the first tilling, so this is one of the main reasons why this form of erosion is difficult to detect, especially if the works are performed after the rain. There are two erosion processes in sheet erosion: breaking of structural aggregates under the impact of raindrops and their transport down the slope, after they have been previously transformed into a suspension. The soil cannot absorb all the water which originates from heavy rains or snow melting, so water runs down the slope causing sheet erosion. Figure 4 presents ski trails in ski centre “Divčibare”.



Figure 4 Sheet erosion on the ski trail in the ski centre “Divčibare”

Rill erosion occurs in two forms, in its weaker form and as more intensive rills. The weaker form of rill erosion is characterised by the appearance of rills, especially in the lower third of the plot on the slope. Actually, during heavy rains, the unprotected soil is readily subjected to erosion. It is visible especially during the spring and autumn.

A more intensive rill erosion is a serious form of erosion. Rills are rather large and deep, so they are difficult to reclaim by simple tillage and they are readily noticeable. Their number and the depth of individual rills depend mostly on the properties of the soil, slope, size and length of ski trails and the species of vegetation along the trail. It is usually estimated that the depth of rills is between 10 and 20 cm, and their width does not exceed 30 cm. This, however, is not the case with the terrains that are not protected. On such terrains, the rills are at the beginning of the similar depth and width, but later on they become increasingly deeper and wider and finally they change into gullies. This happens especially in the lower parts of the plots, where the rills converge and such places are the starting points for the formation of gullies. Figure 5 presents rill erosion in the ski centre “Kopaonik”.



Figure 5 Rill erosion in the ski centre "Kopaonik"



Figure 6 Strong gully erosion on the ski trail Konjarnik - Ski centre "Stara Planina"

Gully erosion also occurs in two forms, weaker and severe gully erosion. Both forms actually start on the terrains with steeper slopes where the soil is poorly protected by vegetation. On such places, at the time of heavy rain storms, water concentrates and forms rills, and then also it forms deeper cuts in the soil. Actually, gully erosion is the continuation of rill erosion, and the weaker forms of rill erosion are transformed into weaker forms of gullies, whereas the more severe rills change into gullies. Figure 6 presents gully erosion in the ski centre "Stara Planina". This process is very fast, especially in poorly binding soils on the slopes on which no measures of protection are implemented.

Landsliding is the most hazardous aspect of erosion. Landslides create a non-uniform slopes, often with several smaller cirques, cracks, mounds, detached soil blocks, and also pools between such blocks. If morass appears on the surface or if small brooks are formed, this leads to the formation of marshy places on the slope. This does not happen in the case of smaller landslides, especially in the shallow ones, when landslide affects only the soil layer and a shallow layer of the loose layer below it. Figure 7 presents the landslides along important structures in the ski centre.



Figure 7 Landslide along the ski lift in a ski centre

5. Required works for mitigation of erosion processes in ski centres

The knowledge on the development of erosion processes and torrential streams in the areas of ski centres is mainly at the level of the estimations, which is insufficient for the undertaking of erosion control measures. The problem is in the fact that risk assessment and the assessment of the demands for undertaking erosion control measures and works is either absent or it is entrusted to the incompetent persons.

It is generally not taken into account that the protection effect can be achieved only by the application of appropriate erosion control measures and works. These works and measures require significant investments. On the other hand, the scope of this type of protection works and measures should correspond to the exact state of erosion and torrents in the area of the ski centre. This in turn requires a reliable data base on the state of erosion and torrentiality, which should precede the design of the ski centre project.

Unfortunately, the practice is different. In ski centres in Serbia, little attention is devoted to the soil protection against erosion processes, i.e. soil conservation along the slopes, and especially on ski trails. It is essential that soil conservation should include protection, management and improvement of soil resources, as a positive approach in which erosion control is supported by the results of good management.

The application of different measures and methods of soil protection and conservation is regarded primarily within the scope of the generally accepted classifications in individual parts of the world. Based on the most widely applied classification in the world, the conservation system includes: biological, biotechnical and technical measures.

Biological and biotechnical measures use the role of vegetation in the aim of minimising the soil erosion.

Technical measures are conditioned by the topography and they include a system of different structures for the control of runoff down the slope.

The main principles of protection of ski trails against erosion in ski centres are based on the following:

- To prevent raindrop splashing on the denuded soil, especially during the period spring-summer-autumn (May-October);
- To prevent runoff from the slopes by various biological measures. The measures include the appropriate selection of grass mixture for the grassing of the slopes and the ski trails;



Figure 8 shows a dense grass cover on a ski trail in a ski centre Semmering, Austria

- To prevent runoff also by biotechnical measures. This involves the establishment of cylindrical hay and twig bales and along the contours, which should prevent the formation of rills and gullies down the slopes. Prevention of runoff and removal of nutrients, as well as the establishment of fresh grass cover are achieved by the implementation of mulch. They are special, readily degradable mixtures, which are degraded immediately after the establishment of the dense grass cover.
- To evacuate water from the slopes and sides safely to the lower parts by technical measures (contour ditches, drainage systems, grips along the trails and lined ditches) and to bring it to the main stems (streams and rivers).
- Because of great quantities of sediment washed down from the sloped terrains, deposit check dams should be built on the main stems, for the checking and prevention of sediment transport into the lower parts.
- During the building of the ski centre, the transport of materials and equipment should be organised by some alternative form of transport (helicopter) and thus prevent the mechanical degradation of the land. This includes the prohibition of transport to heavy machinery over ski trails (bulldozers, excavators, loaders, trucks).

6. Conclusion

The essence of the protection against erosion processes in ski centres is based on the following:

- Conservation of soil cover and its capacity of absorbing as efficiently as possible the effects of raindrop splashing and snow melting.
- Prevention measures which would prevent the runoff down the slope and the establishment of rills and gullies (diversion of water to the margin of the slope, by drainage systems and water evacuation to lower parts by channels).
- Establishment of the system for automatic monitoring of meteorological phenomena (temperature, humidity, rainfall, depth of snow cover, wind speed and direction), which would be extremely useful for the timely application of different erosion control measures.
- Spatial conservation and protection against erosion processes by the application of administrative measures, as well as by the adequate design and planning (spatial and urban) of ski centres.

7. References

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